Vol. IX. No. 8. August 15, 1912.

THE

PSYCHOLOGICAL BULLETIN

GENERAL REVIEWS AND SUMMARIES

RECENT LITERATURE ON THE BEHAVIOR OF THE LOWER INVERTEBRATES

BY PROFESSOR A. S. PEARSE

University of Wisconsin

Protozoa.—Von Prowazek's book (**27**) on the general physiology of the Protozoa contains a full discussion of their reactions to various stimuli.

Mast (**20**) gives an extremely interesting account of the habits and reactions of Lacrymaria, an infusorian sometimes found among organic debris. The body and head of this protozoön are connected by a slender neck, which is capable of extraordinary extension—to eight times the length of the body or fifty times its own length when contracted. Mast gives evidence to show that the extension of the head is due to the pulling action of the oral cilia, rather than the activity of the neck itself; the withdrawal after extension, however, he attributes to the elasticity of the neck.

"The direction in which the neck turns is in all probability regulated by internal factors," and "the direction of locomotion of Lacrymaria in swimming is regulated almost entirely by the movements of the head. . . . The body follows the head in a tortuous course. Lacrymaria moves backward, when free, if stimulated at the anterior end. Practically all the remaining reactions are in the nature of random or trial movements, movements which are determined largely by internal factors, the nature of which is as yet unknown." It is interesting to note that, although the direction of reaction is structurally determined in some protozoans (Paramecium, Oxytricha) and has a definite relation to a particular side of

the body in others which are apparently radially symmetrical (Didinium), Lacrymaria turns its head toward any side. "The same cilia are consequently not always involved in the forward stroke in the process of turning, as is true for Didinium and Œdogonium. During conjunction the reactions of the two individuals are not coördinated. Each responds to stimuli independently." Mast (21) has also made a careful study of the reactions of the flagellate Peranema.

Although Metalnikow's study (23) of the digestion of infusorians is primarily physiological, it contains many points of interest to students of animal behavior. More food vacuoles are formed in an acid medium than in an alkaline one; alcohol and small doses of arsenic stimulate their formation; they appear more slowly at low temperatures, and cease to be formed at 33–34°. The addition of trypsin to the water containing a Paramecium accelerates its digestive processes. Paramecium shows selection in taking its food and digestible particles circulate longer inside the body than others.

Úlehla (30) has made a very careful study, by means of a paraboloid condenser for dark field illumination, of the movements of the flagella of various flagellates, algal swarm-spores, bacteria, and antherozoöids. He gives a comprehensive review of the literature and concludes: (1) Moving flagella describe variable figures, which are, however, definite for each kind and which seldom take the form of simple rotation; (2) flagella have a complicated internal structure; (3) the rate of movement of flagella is much more rapid than has been supposed; (4) the regular beat is easily disturbed and may be modified; (5) flagella exert their propelling influence like oars, not like screws; (6) the movements of flagella may be grouped under six classes.

McClendon (19) points out that the movements of Amœba, when subjected to an electric current or to certain chemical substances, are like the movements of other colloids under similar circumstances. He believes that the behavior of electrolytes in passing the plasma membrane influences the direction of locomotion.

Harper (12, 13) has investigated the geotropic reactions of Paramecia that have ingested particles of iron. He believes that geotropism is due to "a passive orientation not involving the irritability." The Paramecia show an increased upward orienting tendency which persists as long as the particles of iron remain in the posterior end. A magnet placed at one side of a jar containing iron-laden animals causes them to stream upward in the stronger part of the field, and there is a return toward the bottom in the weaker part.

"The magnet is effective in producing this circulation by diminishing the effect of gravity on animals containing iron. It also exerts a passive pull upon them, and they gradually swing into their finally oriented position in a vertical path under the combined influence of the magnet and gravity. The oriented path is consequently a curve."

Wager (31) has made a very comprehensive study of the aggregation forms assumed by Euglena and other microscopic organisms and has reviewed the literature on this subject. He experimented with Euglena, Chlamydomonas, Glenodinium, Volvox, Spirillum, and with masses of finely divided particles in liquids. Euglena usually moves toward the light, and phototropism may interfere with the characteristic aggregations. In the dark or in red light, however, if Euglenæ are crowded close enough together to oblige them to move slowly, gravity causes them to sink downward with the posterior end foremost. Such a downward movement of a mass of Euglenæ brings about a counter current and some individuals may move upward, or they may be brought into a region where they are not crowded, and having been oriented with the posterior end down by gravity, they swim upward. Masses of Euglenæ show a tendency to cling together like all small bodies suspended in liquids. Wager concludes: "The action of the physical forces, gravity and molecular attraction, over which Euglenæ have little or no control, appears, therefore, to play an important part in their life history, and, whilst not inhibiting their power to move, compels them to limit the sphere of their activity to certain definite areas in such a way as to promote a more or less regular dissemination of them through the liquid, and this prevents any undesirable congestion of the organisms in one place." He believes that many of the so-called cases of geotaxis and some phenomena of plankton distribution may be found to be explainable as purely mechanical phenomena.

Desroche (6) has studied the phototropism of Chlamydomonas zoöspores in capillary tubes. These organisms are positively phototropic at times. Changes in light intensity do not affect the rate of their locomotion.

Cœlenterata.—Bohn (1) maintains that Actinia shows a diurnal rhythm, expanding at night and contracting during the day, that is due to light. Nevertheless, though such rhythmical movements are kept up for some time if animals are kept continuously in the dark, individuals kept uninterruptedly in the light will finally expand.

Carpenter (2) contributes some interesting facts in regard to the

habits of the rose coral. This animal is nocturnal and remains contracted during the day or when it is strongly illuminated at night. Its feeding habits differ from those of other corals, and are adapted for capturing plankton. Nervoid impulses resulting from chemical or tactile stimuli applied to a particular polyp may be transmitted to other individuals of a colony. Carpenter believes that branched cells occurring in the mesoglea may serve as adjustors by transmitting impulses from the ectodermal receptors inward.

Parker (24) has studied the reactions of Metridium. He shows that the mesenteric muscles and the annular oral muscle may be caused to contract by stimulating the outside of the body column. When an anemone is cut nearly in two, nervous transmission may take place through any connecting portion of the body except the lips. These facts are considered in connection with histological evidence and Parker concludes that the nervous system lies mostly in the supporting lamella; not, as the Hertwigs believed, in the fibrillar layer at the base of the ectoderm. Parker anæsthetized Metridium with magnesium sulphate and then obtained what he believed to be non-nervous responses from the muscles.

Schmid (29) has observed that *Cereactis aurantiaca* assumes an erect position with the tentacles in the form of a rosette when illuminated, and from experiments in which he used solutions of calcium chromate, calcium bichromate, methyl green, and copper sulphate as color filters, he asserts that the same may be said for red, yellow, green, and blue light. In the dark, however, this actinian assumes a "sleeping position" with the tentacles drooping and the body relaxed.

Annelida.—As a result of tests with nitric, hydrochloric, sulphuric, and acetic acids, Hurwitz (17) asserts that the responses of earthworms to solutions of acids may be ascribed to the effect of the hydrogen ions in such solutions. Judged by its responses, the earthworm's discrimination of weak acids is better than that manifested in man's sense of taste. The earthworm agrees with man in being more sensitive to acetic acid than would be expected from the degree of dissociation in solutions of that acid.

Parker and Parshley (25), studying the earthworm, show that though a moist surface is favorable for locomotion, a dry one acts as a stimulus to bring about avoiding reactions. They also demonstrate that the receptors for stimulation by dryness are situated at the anterior end of the body. The avoiding reaction disappears when the prostomial region is removed or anæsthetized.

Hargitt (11) extends his previous experiments on the behavior of tubicolous annelids to new species. He pays particular attention to what may be called "anti-tropic" light reactions, but also discusses other points. His paper concludes with a general discussion of the laws of behavior with particular reference to the variability of reactions.

Echinodermata.—Holmes (16) has studied the light reactions of the sea-urchin *Arbacia punctulata* in some detail. This animal usually reacts negatively to light and responds to local stimulation by erecting its spines, but it may become positively phototropic in weak light and will move toward the light to get into a shaded region. Cutting the oral nerve-ring does not interfere with local reactions, which are, in fact, usually characteristic in isolated portions of the body, but such an operation destroys the usual negative photic reaction.

Cowles (4) has studied the responses of the sea-urchin and starfish to changes of light intensity. There is a general ectodermal sensitiveness to light in both these echinoderms. The pedicellariæ of Toxopneustes react to an increase or decrease in light, even after they have been removed from the body. Cowles discusses von Uexküll's work at some length.

Mollusca.—Yung (32) shows that, though Helix frequents shady crevices during the day and is active at night, it does not react to light, but rather to heat. The eyes possess little acuity and the characteristic reactions to and from shady places take place after they have been removed.

Lefevre and Curtis (18), in their study of the breeding habits of fresh-water mussels, make some interesting observations on the behavior of the bivalved glochidium larva. The glochidia studied were of two kinds: the hooked, parasitic on the external parts of fish, and the hookless, which attach themselves to the gills of fish. When they pass from the parental marsupium they do not swim but fall to the bottom and remain there until they become attached to a fish or die. When free the two kinds of glochidia exhibit marked differences in behavior. The hooked form frequently makes spontaneous snapping movements with the valves, and may be induced to react more readily by mechanical than by chemical stimulation. The hookless form usually does not respond to tactile stimulation alone, but responds quickly to blood and other chemical substances. Both forms may be anæsthetized by weak solutions of magnesium salts, but chlorides of Na, K, and NH_4 produce the snapping reaction.

Hooked glochidia readily grasp a needle or a piece of paper and "do not relax but remain attached to the object until they die."

Haseman (14) reports some very interesting observations and experiments with three snails of the genus Littorina, which are found in definite zones along the shore at Woods Hole, Mass. Individuals of *L. litorea* located on vertical surfaces between tide marks exhibit oscillatory movements which correspond to those of the tides, but they do not exhibit such movements when on horizontal flat surfaces between tide marks or when below low-tide marks. "The primary directive force for rhythmical movements is the surface film of water. The secondary directive forces are the quiescent position of desiccated individuals, character of surfaces, moisture and food." Light apparently does not influence such movements and this species shows no rhythm in the absence of tidal changes, as Bohn has asserted.

The behavior of several snails of the genus Physa is the topic discussed by Miss Dawson (5) in a very interesting paper. The relation of these animals to "natural environment" is treated at some length. The most important factors limiting the snails to particular habitats are shallow water, minimum amount of shade, few enemies, minimum amount of debris, protection from waves and currents, moderate amount of water weeds, and well aerated water. The secretion of mucus is an important factor in locomotion. Mucus forms an epiphragm to seal the snail in its shell during hibernation, and the spinning of mucus threads plays a prominent rôle in the daily life of Physa. These threads are formed as a snail floats upward through the water. They are not only used as highways in going to and from the surface, but also help to collect food, as their viscosity causes many food particles to become attached to them and these are devoured with the threads. The mucus surrounding the egg masses is never eaten; apparently it is too tough. Physa is omnivorous, though the usual diet is largely vegetable. It passes through a hibernating stage during which no food is taken and the body decreases in size. This snail is not very sensitive to the presence of food substances in the water; it will turn toward food one centimeter away. In a starved individual feeding reactions are called forth by mechanical stimulation, but a well-fed snail must be affected by both mechanical and chemical stimuli in order to feed. Respiration and sensitiveness to air are considered in some detail. *Physa* shows a positive reaction to oxygen and is negative to carbon dioxide. An animal without air in its "lung" is negatively geotropic. The last section of this paper takes up "some psychic phenomena of

Physa." This snail is very sensitive to contact stimuli and is strongly thigmotropic. "A new experience produces a shock to Physa which seems to deprive it temporarily of its sense of gravity." "By the use of the siphon [as a tactile organ] Physa shows that it distinguishes changes in its environment. By a process of association it 're-members' the location of the surface film, the character of the sides of the aquarium, and even the relative depth of the water. It also shows the development of neutral habit." The reactions of young snails differ from those of adults; they show no "fear reactions," and this may be due to the lack of development of the nervous system. Some activities, like the tapping reaction of the siphon, change their character as the snails grow older.

Piéron (**26**) succeeded after twenty-four hours in teaching the cephalopod *Octopus vulgaris* to reach through a side opening in a test-tube, instead of trying to get through the glass, in order to seize a crab inside the tube.

Crustacea.—In a paper too comprehensive for review here, Doflein (**7**) has made a very interesting study of the habits and reactions of certain prawns. He considers color changes, locomotion, feeding, the effect of operations on the nervous system, photoreception, tangoreception, and general habits. The paper is well illustrated.

In another paper Doflein (**8**) calls attention to the fact that the first antennæ (antennules) of certain land crabs have organs of smell that differ somewhat in structure from taste organs found in the same situation on aquatic decapod crustaceans. He believes that such structures changed from tasting to smelling organs as the crabs migrated from the water and took up a terrestrial mode of existence. They are concerned with chemoreception in water or on land, and their adaptability furnishes further evidence that there is but little or no difference between the gustatory and olfactory sensations of many invertebrates.

Chidester (**3**) describes the mating habits of four crabs and gives an extended discussion of sex discrimination in arthropods. In the four species studied, sex discrimination is through tactual stimulation. The female is passive when grasped by a male. Males attempted to mate with other males and with fertilized females of their own species, but did not attempt to mate with individuals of other species. Chidester discusses general topics related to his paper. In the Crustacea as a whole, sex discrimination is kinæsthetic and tactual. "In the Insecta, sex discrimination is by smell; Forel's 'contact-odor sense.' . . . Sexual selection on the part of the female has not

been definitely established in the Arthropoda. We must consider that the successful male is the one who first demonstrates his maleness to the female. Though strength is a great factor, opportuneness of proximity appears to be a greater one." The conclusions of Darwin, Alcock, and others that the mating dances of certain male crabs (Uca) are for the purpose of sexual selection, are thus discountenanced by Chidester without review but perhaps justly.

Matula (**22**) studied the influence of certain ganglia of the central nervous system on the rhythmical respiratory movements of *Squilla mantis*. Extirpation of the cerebral ganglion or of the sub-esophageal ganglion caused little change in the rhythm, but the removal of the first thoracic ganglion caused respiration to cease.

Drzewina and Bohn (**10**) have investigated the reactions of several marine invertebrates in sea water containing a little potassium cyanide. "Sensibility" to light disappears before tactile sensitiveness. The light reactions of some crustaceans were changed from positive to negative.

Schmid (**28**) observed that, though Zœa larvæ were in general negatively phototropic and sank through the water when in the light, they also showed marked sensitiveness to differences in temperature and often made quick backward movements when they came to a place (Temperaturgrenze) where the temperature of the water changed rapidly.

Holmes (**15**) reviews thirty-six papers on the behavior of lower invertebrates, some of which were noticed in this journal a year ago.

References

1. Bohn, G. Comparaison entre les réactions des actinies de la Méditerranée et celles de la Manche. *C. r. Soc. Biol.*, Paris, 1910, **68**, 253–255. Les réactions des actinies aux basses températures. *Ibid.*, 1910, **68**, 964–966. Intervention de la vitesse des réactions chemiques dans la désensibilisation par la lumière. *Ibid.*, 1910, **68**, 1114–1117.
2. Carpenter, F. W. Feeding Reactions of the Rose Coral (Isophylla). *Proc. Am. Acad. Arts and Sci.*, 1912, **46**, 149–162.
3. Chidester, F. E. The Mating Habits of Four Species of the Brachyura. *Biol. Bull.*, 1911, **21**, 235–248.
4. Cowles, R. P. Reactions of the Sea Urchin and Starfish to Changes of Light Intensity. *Johns Hopkins Univ. Circ.*, 1911, 1–7.
5. Dawson, J. The Biology of Physa. Behavior Monographs, 1911, No. 4. Pp. 120, 6 pls.
6. Desroche, —. Sur le phototropisme des zoospores de *Chlamydomonas Steinii* Goros. *C. r. Acad. Sci.*, Paris, 1911, **152**, 890–893.
7. Doflein, F. Lebensgewohnheiten und Anpassungen bei dekapoden Krebsen. *Festschr. R. Hertwig*, 1910, **3**. Pp. 76. 4 plates.

8. Doflein, F. Über den Geruchsinn bei Wassertieren. *Biol. Centralbl.*, 1911, **31**, 706–707.
9. Drzewina, A. Sur la résistance des crustacés au cyanure et les effets sensibilisateurs de cette substance. *C. r. Soc. Biol.*, Paris, 1911, **71**, 535–537.
10. Drzewina, A., et Bohn, G. Modifications des réactions des animaux sous l'influence du cyanure de potassium. *Ibid.*, 1911, **70**, 843–845.
11. Hargitt, C. W. Observations on the Behavior of Tubicolous Annelids. III. *Biol. Bull.*, 1912, **22**, 67–94.
12. Harper, E. H. The Geotropism of Paramœcium. *J. of Morph.*, 1911, **22**, 993–999.
13. Harper, E. H. Magnetic Control of Geotropism in Paramœcium. *J. of Animal Behav.*, 1912, **2**, 181–189.
14. Haseman, J. D. The Rhythmical Movements of *Litorina litorea* Synchronous with Ocean Tides. *Biol. Bull.*, 1911, **21**, 113–121.
15. Holmes, S. J. Literature for 1910 on the Behavior of Lower Invertebrates. *J. of Animal Behav.*, 1911, **1**, 393–400.
16. Holmes, S. J. Phototaxis in the Sea Urchin, *Arbacia punctulata*. *J. of Animal Behav.*, 1912, **2**, 126–136.
17. Hurwitz, S. H. The Reactions of Earthworms to Acids. *Proc. Amer. Acad. Arts and Sci.*, 1911, **46**, 67–81.
18. Lefevre, G., and Curtis, W. C. Reproduction and Parasitism in the Unionidæ. *J. of Exper. Zoöl.*, 1910, **9**, 79–115, 3 plates.
19. McClendon, J. F. Ein Versuch, amöboide Bewegung als Folgeerscheinung des Wechseln des elektrischen Polarisationszustandes der Plasmahaut zu erklären. *Arch. f. d. ges. Physiol.* (Pflüger), 1911, **140**, 217–280.
20. Mast, S. O. Habits and Reactions of the Ciliate Lacrymaria. *J. of Animal Behav.*, 1911, **1**, 229–243.
21. Mast, S. O. The Reactions of the Flagellate Peranema. *J. of Animal Behav.*, 1912, **2**, 91–97.
22. Matula, J. Die Regulation der Atemrythmik bei *Squilla mantis*. *Arch. f. d. ges. Physiol.* (Pflüger), 1912, **144**, 109–131.
23. Metalnikow, S. Contributions à l'étude de la digestion intracellulaire chez les Protozoaires. *Arch. Zool. expér. et gén.*, 1912, **49**, 373–499.
24. Parker, G. H. Nervous and Non-nervous Responses of Actinians. *Science*, 1912, **35**, 461–462.
25. Parker, G. H., and Parshley, H. M. The Reactions of Earthworms to Dry and to Moist Surfaces. *J. of Exper. Zoöl.*, 1911, **11**, 361–363.
26. Piéron, H. Contribution à la psychologie du Poulpe. *Bull. Inst. gén. psych.*, 1911, **11**, 111–119.
27. Prowazek, S. von. Einführung in die Physiologie der einzelligen Protozoen. Leipzig, Berlin, 1911. Pp. 172.
28. Schmid, B. Ein Versuch über die Wärmeempfindlichkeit von Zoea-Larven. *Biol. Centralbl.*, 1911, **31**, 538.
29. Schmid, B. Ueber den Heliotropismus von *Cereactis aurantiaca*. *Ibid.*, 1911, **31**, 538–539.
30. Úlehla, V. Ultramikroskopische Studien über Geisselbewegung. *Biol. Centralbl.*, 1911, **31**, 645–654; 656–676; 689–705; 721–731.
31. Wager, H. On the Effect of Gravity upon the Movements and Aggregation of *Euglena viridis* Ehrb., and Other Microörganisms. *Phil. Trans. Roy. Soc.*, London, 1911, B, **201**, 333–390. Pls. 32–36.

32. Yung, E. De l'insensibilité à la lumière et de la cécité de l'Escargot des vignes (*Helix pomatia* L.). *C. r. Acad. Sci.*, Paris, 1911, 153, 434-436.

RECENT LITERATURE ON THE BEHAVIOR OF THE HIGHER INVERTEBRATES

BY C. H. TURNER

Sumner High School, St. Louis, Mo.

Tropisms

Heretofore it has been thought that all of the Hepialidæ fly only at night. Last summer, on the northern slope of Mt. Hood, J. McDunnough (**29**) found *H. hyperboreus* flying about in the sunlight, between half past two and three o'clock in the afternoon. This was not an accident, for the same behavior was observed on three successive afternoons. McDunnough thinks the severe cold of the evenings in that latitude has caused a change in the habits of the species.

By throwing large flat corks into an aquarium in which the water was only one inch deep, H. H. P. and H. C. Severin (**36**) obtained proof that *Belostoma americanum*, *Benacus griseus*, *Nepa apiculata*, *Ranatra americana*, and *Ranatra kirkaldyi* are positively thigmotactic. Thirty-two out of thirty-five specimens were found hiding against the under-side of the corks.

Cornetz (**10**) thinks the response of ants to light is a tropism.

Turner (**40**) conducted a series of experiments upon the light reactions of a parasitic bee of the family Stelidæ which caused him to form the following conclusions: "These bees are endowed with a pronounced tendency to move in the direction of the rays of light and towards their source, but they do not invariably so act. Light, heat, hunger, sexual restlessness and, perhaps, other factors arouse in these bees an impulse to roam from home. Coupled with this impulse to roam, there is an instinctive tendency to seek freedom in the direction of the rays of light. When following this instinctive tendency fails to bring freedom, the bee tries other methods. In this endeavor many bees make haphazard flights in all possible directions; while others, in a more systematic manner, hover repeatedly before the sides of the enclosure. If such behavior can be called a tropism, then these bees are positively phototactic."

Sensations

The sense of touch of the water-bugs mentioned above is well developed; for, according to the Severins (**36**), the slight disturbance caused by touching a needle to the water near a hungry bug is responded to immediately. These investigators announce that the ability of these bugs to see moving bodies is quite pronounced.

Recently three investigators, working independently, have conducted experiments which convince them that bees possess color vision. These investigators are: Allard (**6**), Lovell (**25**), and Turner (**38**).

Allard's (**6**) experiments were conducted in the midst of a cotton field. He tested the tendency of certain bees (*Mellissodes bimaculata*, Bombus, Entecnia, Apus) to visit each of the following things when arranged in various combinations of threes: normal cotton blossoms, cotton blossoms with the petals removed, petals only of a cotton blossom pinned carelessly to a stem, cloth petals of an artificial rose so arranged as to simulate a cotton blossom, artificial cotton blossoms made out of the petals of an artificial rose covered with natural cotton petals, cotton blossoms made out of paper, single cotton petals pinned to a stem, leaves of cotton so wrapped about cotton petals as to resemble a cotton bud. The three specimens used in any one experiment were arranged either so as to form a triangle or else in a straight line. Allard records the following conclusions: (1) Once visiting insects have entered a cotton field, there is little doubt that their visual powers enable them to discover the blossoms. (2) The size and general appearance of the blossoms do not appear to be of great importance in initiating the process of inspection. (3) A blossom concealed except to bees directly above it is seldom visited. (4) Bees are rarely induced to inspect paper or cloth artifacts; this is probably due to perceptual differences in color and texture. (5) The actual number of entrances into a blossom are small compared with the number of inspections. (6) Bees usually inspect the surface very carefully; hence, although the corolla of the blossom invites the first approach, it is not easy to determine the relative importance of the sense of sight and of the sense of smell involved in nearer inspection. (7) Conspicuousness and coloration are important factors in leading bees to perceive cotton blossoms. (8) A sort of memory of association is developed, so that older or much experienced bees often appear to work among blossoms to a much better advantage than younger bees. The American cotton possesses extra-floral nectaries, but the Asiatic does not. Bees collecting nectar from the outer involucral

nectaries of the American cotton visit similar structures of the Asiatic, but soon depart. Allard thinks a sort of odoriferous cloud enables the bees to find the field itself; but he gives no experimental evidence to support the view.

Lovell's work (25) is partly statistical and partly experimental. He states that, in the portion of the United States which lies east of the 102d meridian and north of North Carolina and Tennessee there are 1,244 species of green or dull-colored flowers, only 233 of which are entomophilous; and many of these are capable of self-fertilization. In his experiments the bees were given an opportunity to select conspicuously colored flowers from dull-colored ones, flowers with corollas from blossoms with the petals removed, colored blossoms from green leaves supplied with honey, honey-bearing surfaces contrasting with the environment from honey-bearing surfaces harmonizing with the environment. The following conclusions are the results of his experiments: (1) Green flowers are not well adapted to entomophily, and many such plants have been derived from larger and more highly developed entomophilous forms. As a whole, entomophilous green flowers are sparingly visited by insects of the less specialized families, and, as a rule, they retain the power of self-pollination. (2) The fact that insects have been observed feeding on over-ripe fruit, or on the glandular secretions of the vegetative organs of plants, or on the excretions of the Aphidæ, or on foliage, or on greenish or brownish flowers, or on dull-colored receptacles which have contained sugar or sweet liquids, affords no proof that conspicuousness is not an advantage to entomophilous flowers. Any surface, whether it is bright or dull-colored, on which there is nectar or honey will be freely visited by bees for stores, after these liquids have once been discovered; but they will not be discovered so quickly on a surface which does not contrast in hue with the environment as they will be on one that does so contrast. (3) As pointed out by Knuth, in the absence of control or comparative observations, the experiments of Plateau upon green or greenish flowers are fallacious and do not prove that "all flowers might be as green as their leaves without their pollination being compromised." (4) When, under similar conditions, bees are given the choice between a conspicuous and an inconspicuous object, they exhibit a preference for the former. This preference is sufficiently marked to account for the development of color contrast in flowers.

Turner's experiments (38) on the pattern-vison of bees were conducted with paste-board artifacts similar to those used by him, a

year ago, in his experiments upon the color-vision of bees. Artifacts constructed out of seven different kinds of color patterns were used. The bees were trained to collect honey from an artifact of a certain definite color pattern. The trained bees were given an opportunity to select artifacts of that color-pattern from one or many artifacts of different color pattern, under the following three conditions: when the artifact to be slected contained honey and the others did not; when some of all kinds of artifacts contained honey; when none of the artifacts contained honey. Of the 518 selections made by the bees, 508 were correct. This warrants the conclusion that bees can distinguish color-patterns. Hence since bees can distinguish colors and the fine details of color-pattern, there is nothing about the visual powers of bees that militates against the theory that the colors and the color-patterns of flowers are adaptations to insect visitors.

Feelings and Emotions

H. H. P and H. C. Severin (36) find that a sudden approach to an aquarium containing Belostomas causes the bugs to flee in all directions from their resting places. This they consider an indication of fear. Under similar conditions, *Nepa apicula um*, *Ranatra americana*, and *Ranatra kirkaldyi* show no such signs of fear.

Wodsedalek (44) thinks that, under certain conditions, the may-fly larvæ show unmistakable signs of fear. He found that larvæ which had been frequently handled exhibited this type of behavior in a marked degree.

Hardy (19) thinks he has discovered in the wasp *Diamma bicolor* signs of anger. He bases this conclusion upon the following observation. The wasp was dragging a cricket into its burrow when Hardy, with a pair of forceps, held the cricket by its hind legs. After tugging and tugging without accomplishing anything, the wasp suddenly stopped pulling, mounted the cricket, seized a portion of the cricket's abdomen in her jaws and stung the insect three times.

Mating Instincts

Hinds and Turner (23) find that the rice weevil is both polygamous and polyandrous.

In studying the behavior of *Calosoma sycophanta*, Burgess (8) found that the same beetles copulated several times during the summer.

Cory (14) describes in detail the copulation of *Sanninoidea exitiosa* Say. He finds that they remain *in copulo* from 51–82 min.

Fuchs (17) observed two males copulating with one female *Cheimatonia brunnata*. He also noticed a male *Larentia bilineata* copulate with a female *Acidalia aversata*.

Turner (40) describes in detail the mating of a parasitic bee of the family Stelidæ.

That certain syrphid flies hover before flowers for long stretches of time, and that several other flies engage in a kind of an aerial dance in which all heads are directed the same way, has been known for several years. Some have considered the first an indication that flies have an æsthetic taste; most students have considered the latter an anemotropism. When Plateau interposed his hand between the fly and the blossom and noticed that it continued to hover there, and when he moved his hand to the right and to the left, forward and backward, and noticed that, in each case, the fly moved in the same sense, he demonstrated the fallacy of the æsthetic taste hypothesis. Pérez (32) has now proposed what, to the writer, seems the true interpretation of both of the phenomena mentioned above. He noticed that the flies hovering before flowers and those engaged in the dances were always males. Whenever a female approached one or more of the males would dart after her. If the female was overtaken, mating would occur and the male would drop out of the dance. These data, obtained by watching the behavior of several species of flies, caused Pérez to conclude that the stationary hovering of certain flies and the aerial dances of others were means of securing mating. This discovery of Pérez places the stationary hovering of the Syrphidæ, the aerial dances of other flies, and the sun dances of certain bees in the same category; each is what has been called a "nuptial ambuscade."[1]

Nest Building and Maternal Instincts

Girault (18) describes the behavior of the adult and larval *Polistes pallipes* Lepelletier during the process of colony formation.

Lozinski (26) discovered a nest of ten cells, constructed by *Osmia bicornis*, in an open glass tube.

Sasscer (35) describes the method of ovipositing of the saw-fly *Tomosthetus mullicinctus* Rohwer.

Hinds and Turner (23) describe the egg-laying habits of the rice weevil.

Parrott (30) describes, in detail, the method of ovipositing of the tree crickets, *Oecanthus niveus* DeGeer, *O. quadripunctatus* Beut., *O. nigricornis* Walker.

[1] C. H. Turner, "The Sun-Dance of Melissodes," *Psyche*, 1908, pp. 122–124.

Calvert (9) found the larvæ of *Mecistogaster modestus* living in water between the leaves of epiphytic bromelids. He thinks this is an evolution from the chance laying of eggs in the bromelids when floods brought the water to that level. The association having once been formed persists, so he thinks, even after the plant is far above the water.

Turner (39) has observed an American Ammophila stocking its nest with subterranean caterpillars.

It is not often that one has the good fortune to observe, within the range of a single genus, an epitome of the evolution of an instinct. In *Synagris*, a genus of Eumenidæ found in the Congo, Roubaud (33) has made such a discovery. *S. calida* L. constructs a nest of several mud cells, stocks them with caterpillars, lays an egg in each, seals the cells, and takes no further care of them. *S. sicheliana* Sauss. lays an egg in each of several mud cells, places in each enough caterpillars to last the larva a little more than a day, and renews the supply daily. When *S. cornuta* L. has completed one cell, she lays an egg in it; but does not stock the cell with caterpillars. When the larva has hatched, the wasp feeds it daily until it is full grown. Then she seals the cell and proceeds to construct a new one.

Fighting and Food-Procuring Instincts

Hardy (19) describes, in detail, the capture and the handling of a tree cricket by *Diamma bicolor*.

Gowdey (1), of Uganda, has observed two specimens of *Bembex tricolor* Dahl carrying off a *Tabanus secedens*.

Davidson (3) observed a large bug (*Lethocerus* (*Belostoma*) *americanus* Leidy) capture and feed upon a fish (*Lucius americanus* Gmelin).

Banks (7) discovered that one of the phorid flies attacks myriapods.

McDermott (28) observed a young half-winged bug feeding upon the larvæ of the tent-caterpillar.

Knab (24) discovers that a genus of mosquitoes (Megarhinus) does not suck blood, but feeds upon fruit and that its mouth-parts have been especially modified for that purpose.

According to the Severins (36) both Belostoma and Nepa are carnivorous.

Parasitism, Commensalism and Symbiosis

T. L. Patterson (31) has conducted some experiments which have caused him to conclude that the sarcophagids are scavengers and not parasites.

Roubaud (33) describes several commensals and parasites of the solitary wasps of the genus Synagris.

Wheeler describes two new ant guests: a pseudoscorpion (*Chalanops dorsalis* Banks) (41) and a coccinellid beetle (*Brachycantha quadripunctata* Mels.) (43) and gives a list of the hosts of five Xenodusæ (42).

Enslin (15) describes a small cicada (*Gargara genistæ*) functioning as an "ant cow." The larvæ and nymphs rest on a plant with the beak of each penetrating the plant tissues. The ant appears in the rear and feels the abdomen of the cicada with her antennæ. Immediately the cicada protrudes an anal tube on the tip of which appears a drop of clear liquid, which is swallowed by the ant.

Cremastogaster difformis Sm. (4), a Javanese ant, excavates its nest in the end of dead branches. In certain places these nests are filled with rain water and a mosquito (*Harpagomyia splendens* Meijere) breeds therein. In breeding mosquitoes and ants together, Jacobson found that the mosquitoes spent much time on the upright rod that supported the nest. When an ant passed between the legs of the mosquito, it was caressed by the mosquito and between the ant's wide open jaws there appeared a drop of liquid which was swallowed by the mosquito.

In the literature much emphasis has been placed upon the symbiotic relation of certain animals to certain plants. Recently Escherich (16) has made a careful study of the so-called symbiosis between ants and *Humboldtia laurifolia*, a plant with hollow internodes. He collected the following data: (1) Only a small number of the cavities in the stem contained ants. (2) The following genera of ants were found in the cavities: *Tapinoma*, *Monomorium*, *Cremastogaster*, etc., all genera that are found elsewhere than in the stems of these plants. (3) The ants were anything but aggressive. (4) Many of the branches containing ants showed scars caused by woodpeckers. Escherich concludes that this is evidently not a symbiotic, but a parasitic relation; the ants being the parasites.

Miscellaneous Instincts

Migrations.—Hill (**22**) describes dragon flies migrating in swarms.

July 9, 1911, a moth (*Tortrix fumiferana* Clemens) entered Philadelphia in such numbers as to interfere with traffic and to cause the shop people to close their doors (**2**).

Hibernation.—Herrick (**21**) thinks that, in the south, the agamic adults of the cabbage aphis (*Aphis brassicæ*) hibernate.

Homing

During the year Cornetz (**10, 11, 12, 13**) has produced several papers on the homing of African ants. These papers reiterate the same points given in the papers by him that were reviewed in this Bulletin last year. He lays especial stress upon the statement that ants have an awareness of distance and of direction, which has been obtained independently of the sense of sight and of the sense of smell.

Santschi (**34**) has recently conducted a series of well-planned field experiments upon the African ants. These experiments were so arranged as to give the ants an opportunity to find the way home under the following conditions: when the odor has been removed from a portion of the trail; when a portion of the trail and the ant upon it is shifted bodily to a new position; when the direction of the impinging light rays is shifted from time to time by means of mirrors; when the ant is placed in a new environment. Santschi concludes: (1) There are two kinds of trails found among ants: trails along which the ants are guided by the olfactory and topochemical senses, and trails along which the ants are guided by perceptions which are largely visual. (2) Among the Tapinomas, and perhaps among other harvesting ants, the trails are started by odors intentionally deposited by a single worker. (3) Such an intentionally scented trail, although not slavishly followed, is utilized by workers to teach other workers the way to a source of food. (4) The trace of odor is not sufficient to explain fully the orientation of the ants that follow it and it is supplimented by contact ideas. (5) As a rule, orientation among ants is a complex phenomenon based upon a variety of sense stimuli, the one predominant depending upon the species and the conditions. (6) Odors, topochemical stimuli, visual images, the direction of the rays of light, tactile sensations, muscular sensations, and auditory sensations form a psychic complex which serves as a flexible guide to behavior. (7) The chief sense-organs that function in ant behavior

are: antennæ, eyes, tactile tegumentary hairs, chordotonal organs, and muscles.

Memory and Learning by Association

Allard (6) thinks that the bees visiting cotton blossoms display a kind of memory or association.

By patient experimenting, Wodsedalek (44) trained may-fly nymphs to move against the light towards a stone, the position of which was shifted from time to time, and to swim considerable distances towards food held in forceps. The latter was accomplished in the following manner. Algæ, held in forceps, were presented to a hungry nymph. When the insect seized the algæ, the experimenter pulled gently and thus caused the nymph to follow. Later he would hold bits of algæ near a nymph and, when the young may-fly approached, withdraw the forceps a little. After four weeks of such training, many would swim considerable distances towards food, and some would swim towards the experimenter as soon as he entered the room. At the end of two and a half months, as soon as Wodsedalek entered the room, the majority of the nymphs would swim towards him and claw against the side of the aquarium. One specimen came to the top of a stone, and partly into the air, to obtain the food. Untrained specimens never behaved in this manner.

Szymanski (37) has used the same method in investigating the behavior of young cockroaches that was employed by Yerkes in studying the behavior of mice; namely, punishing the subject with an electric shock whenever it makes a wrong choice. The young roaches were given an opportunity to pass from a well-lighted apartment into a dark one. Following its natural tendencies, each roach started to enter the dark chamber. As soon as it did so, it received an electric shock which caused it to dart back into the light. After being repeatedly punished for entering the dark chamber, the roach learned to turn back as soon as it reached the shadow. To the best of my knowledge, this is the first time that this electrical method of punishment has been used in the investigation of insect behavior.

References

1. [Anon.]. Bembex Preying upon Tabanidæ. *Bull. Entom. Research*, London, 1911, 2, 182.
2. [Anon.]. *Entomological News*, 1911, 22, 371–372.
3. [Anon.]. *Entomological News*, 1911, 22, 372–373.
4. [Anon.]. *Entomological News*, 1911, 22, 466.
5. [Anon.]. Le retour au nid chez les Fourmis. *Le Naturaliste Canadien*. Quebec, 1911, 38, 29–31.

6. ALLARD. Some Experimental Observations Concerning the Behavior of Various Bees in their Visits to Cotton Blossoms. *Amer. Nat.*, 1911, **45**, 607–622; 668–685.
7. BANKS, N. A Curious Habit of One of Our Phorid Flies. *Proc. Entom. Soc. Washington*, 1911, **13**, 212–214.
8. BURGESS, A. F. *Calosoma sycophanta:* Its Life History, Behavior and Successful Colonization in New England. *U. S. Dept. of Agri., Bureau of Entomology*, Bull. 101, 1911, 1–94; Pls. I.–IX.
9. CALVERT, P. P. Habits of Plant-Dwelling Larva of *Mecistogaster modestus. Entom. News*, 1911, **22**, 402–411.
10. CORNETZ, V. L'Oeil-boussole de la Fourmi d'après Santschi. *Revue des Idées*, 1911, Oct. 15, 1–7.
11. CORNETZ, V. Observations à faire à propos des trajets de la Fourmi. *La Feuille des Jeunes Naturalistes: Revue Mensuelle d'Histoire Naturelle*, 1911, **41**, 1–6.
12. CORNETZ, V. Das Problem der Rückkehr zum Nest der forschenden Ameisen. *Zsch. f. Insektbiol.*, 1912, **7**, 181–183; 218–223; 312–316; 347–350.
13. CORNETZ, V. Quelques observations sur l'estimation de la distance chez la Fourmi. *Bull. de la Société de l'Afrique du Nord*, Feb. 15, 1912.
14. CORY, E. N. Notes on the Egg-Laying Habits and Emergence of Adult *Sanninoidea exitiosa* Say. *J. of Econ. Entom.*, 1911, **4**, 332–336.
15. ENSLIN, E. *Gargara genistæ* F. und *Formica cinerea* Mayr. *Zsch. f. wiss. Insektbiol.*, 1911, **7**, 19–21; 56–58.
16. ESCHERICH, K. VON. Zwei Beiträge zum Kapitel "Ameisen und Pflanzen." *Biol. Centralbl.*, 1911, **31**, 44–51.
17. FUCHS, F. Unnatürliche Copula bei Lepidopteren. *Zsch. f. wiss. Insektbiol.*, 1911, **7**, 359–360.
18. GIRAULT, A. A. Incidental Observations on a Queen of *Polistes pallipes* Lepelletier while Founding a Colony, Including Fragmentary Biological Notes. *Bull. Wis. Nat. Hist. Soc.*, 1911, **9**, 49–63.
19. HARDY, A. D. The Stinging of *Gryllotalpa coarctata* by *Diamma bicolor. Victorian Naturalist*, 1911, **28**, 33–38.
20. HERMS, W. B. The Photic Reactions of Sarcophagid Flies, Especially *Lucilia cæsar* and *Calliphora vomitoria. J. of Exper. Zoöl.*, 1911, **10**, 167–226.
21. HERRICK, G. W. The Cabbage Aphis (*Aphis brassicæ*). *J. of Econ. Entom.*, 1911, **4**, 219–224.
22. HILL, M. D. *Entom. News*, 1911, **22**, 419–421.
23. HINDS, W. E., and TURNER, W. F. Life History of the Rice Weevil (*Calandra oryza* L.) in Alabama. *J. of Econ. Entom.*, 1911, **4**, 230–236; Pl. VII.
24. KNAB, F. The Food-Habits of Megarhinus. *Psyche*, 1911, **18**, 80–83.
25. LOVELL, J. H. The Color Sense of the Honey Bee: The Pollination of Green Flowers. *Amer. Nat.*, 1912, **46**, 83–107.
26. LOZINSKI, P. Ueber einen eigentümlichen Nestbau von *Osmia Bicornis. Zsch. f. Insektbiol.*, 1911, **7**, 223–230; 316–322.
27. LUND, E. J. On the Structure and Use of Photogenic Organs, with Special Reference to the Lampyridæ. *J. of Exper. Zoöl.*, 1911, **10**, 415–468.
28. MCDERMOTT, F. A. The Attack of a Larval Hemipter upon a Caterpillar. *Proc. Entom. Soc. Washington*, 1911, **13**, 90–91.
29. MCDUNNOUGH, J. Peculiar Habits of a Hepialid Moth. *Canadian Entom.*, 1911, **43**, 289–292.

30. PARROTT, R. J. Oviposition among Tree Crickets. *J. of Econ. Entom.*, 1911, **55**, 216–218, Pl. VI.
31. PATTERSON, T. L. Investigations of the Habits of Certain Sarcophagidæ. *U. S. Dept. of Agriculture, Tech. Series*, No. 19, part III., 25–32.
32. PÉREZ, J. Sur quelques particularités curieuses du rapprochement des sexes chez certains Diptères. *Bull. Scientifique de la France et de la Belgique*, 1911, 7th Series, **45**, 1–14.
33. ROUBAUD, E. The Natural History of the Solitary Wasps of the Genus Synagris. *Ann. Rept. Smith. Inst. for 1910–1911*, 507–526. Pl. 1–4.
34. SANTSCHI, DR. F. Observations et remarques critiques sur le mécanisme de l'orientation chez les Fourmis. *Rev. Suisse de Zool., Ann. de la Société Zoologique Suisse, etc.*, 1911, **19**, 304–338.
35. SASSCER, E. R. Notes on a Sawfly Injurious to Ash. *Proc. Entom. Soc. Washington*, 1911, **13**, 107–110, Pl. VII.
36. SEVERIN, H. H. P. & H. C. Habits of *Belostoma* (= *Zaitha*) *flumineum* Say and *Nepa apiculata* Uhler with Observations on Other Closely Related Aquatic Hemiptera. *J. of N. Y. Entom. Soc.*, 1911, **19**, 99–108.
37. SZYMANSKI, J. S. Modification of the Innate Behavior of Cockroaches. *J. of Animal Behav.*, 1912, **2**, 81–90.
38. TURNER, C. H. Experiments on Pattern-Vision of the Honey Bee. *Biol. Bull.*, 1911, **21**, 249–264.
39. TURNER, C. H. A Note on the Hunting Habits of an American Ammophila. *Psyche*, 1911, **18**, 13–14.
40. TURNER, C. H. Notes on the Behavior of a Parasitic Bee of the Family Stelidæ. *J. of Animal Behav.*, 1911, **1**, 374–392.
41. WHEELER, W. M. Pseudoscorpions in Ant Nests. *Psyche*, 1911, **18**, 166–168.
42. WHEELER, W. M. Notes on the Myrmecophilous Beetles of the Genus Xenodusa, with a Description of the Larva of *X. cava* Leconte. *J. of N. Y. Entom. Soc.*, 1911, **19**, 163–169.
43. WHEELER, W. M. An Ant-Nest Coccinellid (*Brachycantha quadripunctata* Mels.). *J. of N. Y. Entom. Soc.*, 1911, **19**, 169–174.
44. WODSEDALEK, J. E. Formation of Associations in May-Fly Nymphs *Heptagenia interpunctata* Say. *J. of Animal Behav.*, 1912, **2**, 1–19.

RECENT LITERATURE ON THE BEHAVIOR OF VERTEBRATES

BY PROFESSOR MARGARET FLOY WASHBURN

Vassar College

Fish.—Copeland (**2**) finds that the puffer bites much oftener at packets containing food than at empty packets of similar appearance; this discrimination is abolished by cutting the olfactory nerves, and reëstablished on their recovery.

Loeb and Wasteneys (**13**) have observed that the maximum temperature to which Fundulus may safely be transferred varies with

the concentration of the water and is affected by the presence of salts. The fish may be immunized to a temperature of 35° by being previously kept for thirty hours in water at 27°.

Sumner (**23**) has observed the protective adjustment of the markings of flatfish to the background. Observations were made with the fish on natural and artificial grounds. The pigment pattern is adjusted not only to the brightness of the ground but to its pattern: the plates show arrangements to correspond with large and with small black and white checks; arrangements quite foreign to the previous experience of individual or race. The pattern assumed is constant for a given ground. The vertical walls have some influence; the ceiling has none. The pigment changes do not occur if both eyes are destroyed; hence their source is retinal. Since the absolute degree of illumination has little effect, the stimulus must be the ratio of direct to reflected light. The changes occur when the fish is buried in the sand or has its skin covered with a mask. The fish shows no ability to choose between two grounds that one to which its pigmentation is adapted. It may be remembered that Minkiewicz has claimed such a power for the crab, but that Pearse has been unable to confirm his observations.

Parker (**16**) has recently made experiments to test the effect on various kinds of fish, which he believes can hear, of the noises made by motor boats and guns. It was found that "the sounds produced by motor boats are extremely faint under water, and have little influence on the movements and feeding of fishes. . . . Single explosive sounds, like the report of a gun, may startle fish and cause them to cease feeding, but these responses are also temporary and local." It is pointed out that certain fish, like the drumfish and the squeteague, produce noises that are connected with sex attraction, and that therefore it might be possible to use artificial noises as a lure.

A very interesting suggestion, connecting the adjustment of pigmentation in certain fishes to the background on which they lie, with possible sensibility of their eyes to color, has been made by von Frisch (**6**). *Phoxinus lævis* has this power of adjustment, but loses it if blinded, showing that the reaction is a retinal one. Now two equally bright fish may be placed, the one on a gray, the other on a yellow ground, and if the grounds are properly chosen, the fish will not change their brightnesses, showing that the two grounds are of equal brightness so far as the sensitiveness of the fish is concerned. But after a few hours spent on these grounds, the fish on the yellow shows a yellow stripe which does not appear on the other fish. This

proves, von Frisch argues, that the light has had a chromatic effect on the retina. If such is the case, there is no reason why the fish should not have color vision. This is drawing evidence from a new source on the problem of color-vision in an animal (see the dispute between Hess and Bauer reported in the corresponding number of this BULLETIN for last year).

Amphibia.—Our opinion of the ability of frogs to learn has been raised by the investigations of Schaeffer (**19**). Specimens of *Rana clamata*, *R. sylvatica*, and *R. virescens* learned in from four to seven trials to avoid hairy caterpillars, and chemically treated worms also were soon avoided. An electric shock associated with food inhibited the feeding instinct altogether for some days. Schaeffer calls attention to the fact that the frogs learned to avoid the disagreeable food in two ways: either by taking it into the mouth and rejecting it, or by swallowing it. In the former case, rejecting movements entered into the formation of the habit; in the latter case, the habit must have been formed wholly in nervous tissue, and under such circumstances a habit might appear to be suddenly formed when its growth had really been gradual though invisible. The difference between the speed of learning shown by his frogs and the slowness of Yerkes's frogs in learning a labyrinth the author explains as due to the fact that the feeding instinct, which was not involved in the work of Yerkes, is exercised with regard to a great variety of dissimilar stimuli, and hence its mechanism must be very plastic. Strong objection is made to the statement by Washburn and Bentley in their article on the formation of associations in the chub: "In general it may be prophesied that the more deep-rooted and essential the instinct appealed to by the experience to which an animal is subjected, the more rapidly will the animal profit by experience." The authors of this statement did not mean to imply that these characters in an instinct were the only ones affecting its modifiability. The presence of a psychic accompaniment to the behavior of his frogs is concluded by Schaeffer from the fact that they very carefully examined the food supplied to them, after they had had unfavorable experience with it. This examination differed from instinctive examination, for its cause was the individual experience of the frog. The nature of this psychic process the author describes by using Morgan's term "defining the construct" of hairy caterpillar.

In connection with prophecies that fail, it is rather amusing to find in Hargitt's (**8**) paper on the tree frog a prophecy that is falsified by Schaeffer's results. Hargitt observed that a tree frog which had

caught and been stung by a wasp went through the same performance next day without, apparently, having profited by its lesson, and he says: "It may be doubted whether amphibia show any particular discrimination based on that type of experience." Hargitt's work was done on the American species *Hyla versicolor*, and was supplemented by a less complete study of the European *H. arborea*. The animals were subjected to varying degrees of daylight, and to different air and water temperatures. Strong light lightens the skin color, as does high temperature: Parker found that in lizards light and high temperature caused opposite effects. Neither darkness nor low temperature had any direct effect on the tree frogs. Biedermann's hypothesis that contact stimuli are important was tested with different stimuli, as well as with individuals whose toe disks were clipped off, and even with section of the spinal cord; the results were negative. The great variability of the phenomena observed leads Hargitt to think that emotional factors are involved in their production. Sometimes mere handling would produce the changes. "I even," says he, "tried the effect of merely close scrutiny without any jostling or moving of the jars, and found that where a specimen could be brought to *observe* that it was observed, there was often a color change quite as evident as the others." In certain instances where light stimuli on one day produced response and on the following day failed to do so, the suggestion is ventured that "the creature had acquired such familiarity with conditions as to dissipate to a degree its emotional sensitiveness." One can imagine the reaction of Professor Loeb to the following concluding remark, which is however very gratifying to the psychologist: "There are other minds than ours, and they share something in common with us in those psychic powers which count for something in the stress of evolution, and as behavior in its manifold aspects gives expression to the endless struggle it is not strange to find involved therein the psychic along with other factors which go to constitute the organism and its environment."

Cummings (5) contributes a brief description of the courting behavior of a British salamander, *Molge palmata* Schneid.

The spotted newt has had its food and chemical sense tested by Reese (17). In securing food, both sight and smell play a part, the latter being more important. Inedible objects are followed and sometimes seized, but not swallowed; and when fatigued so that it will no longer follow such objects the newt will usually still react to food. The head is much the most sensitive part of the body to chemical

stimulation. All other parts of the body are equally sensitive. Cutting the olfactory nerves abolished all response to food, but a negative response to a .5 per cent. solution of acetic acid was unchanged, and the greater sensitiveness of the head was maintained, from which the author concludes that it is probably due to the sensitiveness of the oral and nasal mucous membranes, rather than to smell proper. A strong sugar solution caused no reaction. Quinine produced a negative reaction when applied to the head, but no response from other regions. Some animals reacted negatively to a 1 per cent. solution of common salt applied to the head; a 4 per cent. solution was necessary to produce reactions from other parts of the body. Very marked negative reactions to potassium hydroxide and to acetic acid occurred. Ethyl alcohol caused less reaction than might have been expected. Cocaine has apparently no effect upon the skin of this newt; applied to the nasal and oral mucous membrane in a 5 per cent. solution "it temporarily inhibits the feeding reaction and diminishes the sensitiveness to acid solutions squirted upon the head. This result may be due to the general effect of the cocaine upon the system." The writer quotes from the present reviewer the term "telæsthetic sense" as descriptive of the chemical sense. The term, which is Lloyd Morgan's, should be "telæsthetic taste," and is descriptive of the sense of smell in a water-dwelling animal. "Telæsthetic sense" does not properly describe smell, for the senses of sight and hearing are also telæsthetic.

Birds.—Hunter (11) used three mazes with pigeons; the first was that of Rouse, the second more complex, and the third was one whose paths could be shortened. Four males and four females were given three tests each a day. With Rouse's maze, the time curves began much lower and fell more abruptly than in Rouse's own experiments; probably because in his tests the birds could see from one compartment into another, since he used wire rather than wood partitions. Hunter found that memory for this maze was practically perfect after four weeks. With the second maze the error curve fell much more slowly, owing, the author thinks, to the complexity of the maze and to the interference of habits from the first maze. The time curves, however, fell more rapidly in the case of those birds that had had experience with the first maze. Tests were made with the maze rotated 90°, 270°, and 360°. Some birds were confused at 90° but perfect at 270°; with others the reverse tended to be the case. One bird was confused at both positions. "After sixteen days training in these two positions, all the birds were perfect at 360° rotation."

In explanation, Hunter suggests that the birds which were not confused in a rotated position must have been depending on visual cues from within the maze, while those which were confused were depending on visual cues from without the maze. It is then necessary to suppose that those which were confused at one rotation but not at another changed their system of cues when the maze was placed in a new position, an hypothesis which "suggests the complexity of the animal mind for types as high as the pigeon." The final perfect records at 360° may be explained either by a persistence of the original learning, or by the acquisition of a system of cues that is undisturbed by any rotation. The birds throughout depend on visual cues and do not make the type of errors in the shortened maze, such as butting into the walls, characteristic of an animal guided by kinæsthetic data.

In the second part of Herrick's (9) study of nests and nest-building in birds, we have sections on the analysis of increment nests on the basis of behavior, and on variations in the nests of certain birds. In Part III. careful descriptions are given of the building behavior of the robin, oriole, and red-eyed vireo. An interesting feature of the robin's building is the fact that the molding movements are always made in opposite directions on successive visits to the nest, although nothing can be detected in the appearance of the nest that would give the bird a clue as to which direction she had turned in at the previous visit. The history of the nest-building instinct is outlined as follows: incubation arose through the instinct to guard and to conceal by covering with the body; "increment nests may have arisen . . . through an earlier practice of collecting materials of any description to cover the eggs upon leaving them to look for food. All such would be scattered to some extent upon reëntering the nest to cover and guard; some, however, would remain to form a rude rampart or wall of circular form, and this would be advantageous in holding the eggs to a focal point."

Haggerty (7) notes an instance of pure instinct in a young sparrow hawk which had fallen out of the nest, and which used towards a piece of roast beef the behavior that would have been appropriate for living prey.

The series of Behavior Monographs is inaugurated by Breed's (1) study of the instincts and intelligence of the chick. Part I. is devoted to the chick's instinctive activities. The behavior of the chick while still in the shell was observed by bringing the eggs, just after the shell was chipped, under an electric light and breaking away some of the shell. Breed is inclined to think that a movement much more

important than pecking in the emergence from the shell is a lifting movement of the head. "Chicks appeared to break the shell in two by a lifting, struggling movement of the head accompanied by a stretching, straightening movement of the legs." A tapping sound is heard before the shell is chipped at all, but a somewhat similar sound is heard after so much of the shell has been removed that the beak is no longer in contact with it. Morgan and Mills agree that the stimulus to the drinking reaction is the touch of water on the bill. Breed, by keeping chicks from drinking for three days after hatching, found that the drinking reaction was given "to the surface of smooth white note paper, the edge of white glazed kymograph paper, or the edge of a glass dish;" the stimulus being evidently visual. The effect of deferring the pecking reaction was studied by keeping some chicks in the dark for a number of hours after hatching; it was found that pecking was decidedly more inaccurate in these chicks, but that practice soon made up the deficiency. The effect of imitation on the pecking reaction was studied by comparing the records of accurate pecking made by one brood with those made by a younger brood placed with the older one to profit, if possible, by imitating the latter. No such beneficial influence was observed. Possibly, the author suggests, the effect of social influence may have been exerted in the direction of increasing the intensity and speed of the pecking, though not its accuracy. An important observation is that the chicks ate readily in complete darkness. One of the fundamental methods upon which Hess's far-reaching conclusions with regard to vision in the lower animals are based is derived from the assumption that if animals cannot see food on the ground they will not eat it. There must, however, be some explanation for the refusal to feed, under certain visual conditions, shown by the animals in the tests made by Hess, Katz, and Revész. A very careful record of the development up to the twenty-fifth day of the pecking reaction as regards the accuracy of its three components, striking, seizing, and swallowing, was kept. Improvement was very rapid during the first two days, and was practically complete at the eleventh day. Seizing remained imperfect longer than the other components. The belief of some observers that the reaction is perfect from the outset is probably accounted for by the fact that the striking component is very nearly so by the fifth day, and is "seldom widely erroneous."

In Part II. we have a report of the learning processes of the chick as tested by the visual discrimination method. Two compartments were offered, through one of which escape might be made to

the cage where the other chicks were kept and food was to be had. Cards were placed at the entrance to the compartments to serve as visual stimuli. Electric shocks furnished the punishment for wrong choices. Color differences, brightness (black-white) differences, form differences, and size differences, were used as stimuli. The principal object was to study the learning process, and the results bearing on this will be stated first; the incidental observations on color discrimination will be discussed later. The chicks succeeded in acquiring habits of choosing one color or brightness rather than the other, and in responding selectively to a small and a large opening, through which they had to pass in order to escape. They failed to discriminate forms, either as figures pasted on the cards, or as differently shaped openings. The doctrine of formal discipline fails to be confirmed, in so far as learning to discriminate black and blue did not facilitate learning to discriminate sizes. "Of nine chicks perfectly trained in black-blue, five made perfect persistence tests after an interval of thirty days." On the whole, the chicks that learned most rapidly remembered longest. The use of the electric shock tended to produce a negative response to the stimulus to which it was attached, rather than a positive response to the other stimulus.

The principal conclusions with regard to color vision which the author considers indicated by his experiments are two: that blue has a very light brightness value for the chick, and that it has a color value as well. The first conclusion is based on the fact that one chick which preferred white to black and yellow to black preferred blue to yellow and to orange; while another chick that had been trained to choose black rather than white preferred black to blue but displayed no preference between blue and white. Although the reviewer found indications that the rabbit, too, sees blue as much lighter than the human subject does, she does not feel sure that the number of tests given by Breed (in many cases only ten) was sufficient to exclude chance and establish the fact of a preference. That blue is seen as a color is argued from the fact that chicks which had been trained to avoid blue in the black-blue combination avoided blue in any combination, even with white; the inference being that if absolutely recognized, it must have been seen as a color. But it is not to be assumed as certain that an animal cannot recognize an absolute brightness to a certain extent; that is, that the gray seen in place of a blue cannot be identified and avoided in successive experiments. In the experiments of Washburn and Abbott (26) there was some indication that a gray was thus identified. And in Breed's experi-

ments there may have been other peculiarities than either color or brightness leading to the identification of the blue cards: were the same cards used whenever blue was employed as a stimulus?

Strong (**22**) has combined an anatomical study of the smell organs in birds with an experimental test of the possibility of causing smell to influence a bird's behavior through association. The morphological study was carried out on material representing twenty-seven out of the thirty-five existing orders of birds. From it the writer concludes that "the olfactory organs of birds are of too great size to be set aside as non-functional," but that as one passes from the lower to the higher orders of birds there is a tendency towards retrogression in these organs. The crow family, sometimes considered to be the highest birds, show extremely minute smell organs. "The sense of smell has evidently been disappearing in birds with the great development of vision. It seems not at all improbable that the sense of smell may be practically lost in the passerine birds." The fulmar, a bird which takes long sea-flights, has enormously developed olfactory apparatus, suggesting Cyon's hypothesis that it may be used for orientation. It will be remembered that Watson, testing this hypothesis for terns, got negative results. Strong finds, however, that the olfactory organs of the tern are very small, so that the use of those organs in guiding the flights of other birds is not ruled out by Watson's observations. Strong's experimental work was performed upon the ring dove. A labyrinth was used, with a large central chamber, and four small chambers, one opening from the middle of each side. Food could be placed in any one of the four small chambers and remain invisible from the central compartment. Currents of air could be sent from each of the four small chambers into the central compartment by means of a siphon arrangement outside each small chamber; the air currents entering one of the four chambers were passed through a bottle containing an odorous substance. General ventilation was provided by an air-pump connected with an exhaust funnel in the middle of the roof of the labyrinth. To test the actual diffusion of the odor from the small chamber into the large one, the following method was adopted. The strength of the odor of an ammonia solution was compared with that of the smell of bergamot which was to be used in the experiments, and when the two were judged equal, the ammonia was placed in one of the odor bottles and its diffusion tested with wet litmus paper. It was found that the odor was diffused in a semicircular area whose radii converged at the entrance of the odor chamber, and whose front extended

to the region of the exhaust funnel. Tests were also made by the experimenter, lying on the floor inside the enclosure; the odor of bergamot could be detected eighteen inches from the point of emergence. The central chamber was five feet square. Oil of bergamot was the smell stimulus chosen for use, although less satisfactory tests were made with cologne, musk, and violet sachet; and food was to be found in the small chamber from which the odor emerged. The birds had previously been accustomed to the apparatus. The results showed that when bergamot was used, the percentages of choices of the odorous chamber rose for all four birds tested considerably above the twenty-five per cent. which chance would produce. It is to be regretted that only the total percentages are stated, rather than the choices of each successive day, so that no data on learning are furnished. The conclusion that the birds were stimulated by the bergamot seems warranted. That general sensation is not concerned the author infers from the small amount of odorous material that was used as a stimulus. A few observations on birds at liberty and in a zoölogical garden are also reported, but the results are not conclusive.

Craig (3) has been continuing his studies of the vocal expressions of emotion in pigeons. The paper on those of the mourning dove was written chiefly, the author tells us, as a basis of comparison for that on the passenger pigeon. Most of the peculiarities of the latter bird can be traced to its extreme gregariousness. The softer, cooing notes of this pigeon, for instance, which could not have much effect in a noisy and populous community, have degenerated, and the louder sounds have developed into "shrieks, chatters, and clucks." Two females not infrequently lay in the same nest, an occurrence which is much rarer in less social species. The testimony of various observers is quoted to show that orphan young are fed by foster-parents. The courting behavior of these birds is described as much rougher than that of other pigeons.

The interesting discovery has been made by Craig (4) that egg-laying in the female ring-dove may be produced by the courting behavior of the male, without actual fertilization. "The influence of the male in inducing oviposition is a psychological influence." The word "psychological" is perhaps a little extreme here: the tactile stimuli produced by the male's preening of the head and neck of the female might operate reflexly.

Mammals.—Slonaker (21) has investigated the activity, growth, and longevity of the white rat. Eight rats were chosen and divided

into two equal groups; the members of one group were placed in revolving cages whose revolutions were registered on a kymograph; those of the other group were kept in ordinary cages as controls. The results show that the daily activity increases rapidly during the first third of the animal's life and then decreases gradually until death. The change in the amount of the daily activity is rhythmical. During youth and old age the activity is more or less distributed through the twenty-four hours; in middle life it is nocturnal. The female is much more active than the male; the males are much heavier. About three-fourths of the whole amount of work done during the animal's lifetime is done before reaching middle age. During the last 30 per cent. of life only one-eighth of the total work was performed. The unexercised males are much heavier than the exercised ones, and reach their maximum weight at an earlier age. The exercised rats had shorter lives than the unexercised ones; they were more active, alert, and bright in appearance.

Hunter (**12**) records the observation that two white rats which had been accustomed to being dropped into a box as a preliminary to being returned to their living cage and to food at the close of certain experiments with them, after two hundred and four days of this experience dropped themselves into the box. This is in opposition to the results obtained by Thorndike with cats, which did not learn to drop themselves into a box after being dropped in by the experimenter. Cole, on the other hand, found that raccoons did display this type of behavior. The inability of Thorndike's cats to perform such an act was taken as evidence against their possession of an idea of being in the box as a preliminary to food. The reviewer's work on the rabbit (**26**) furnished proof that these animals after only a few days' experience of being dropped into a box between tests will jump in of their own accord and wait for the next test. Hunter rightly points out that this behavior is not necessarily evidence of ideas: "the very perception of the box has acquired motive power."

In the study by Hoge and Stocking (**10**) comparing punishment and reward as motives, albino and black and white rats were used. The punishments were light electric shocks; the reward was milk-soaked bread; the problem was brightness discrimination in a Yerkes box. It was found that punishment produces quicker learning than reward, and a combination of the two is most effective of all.

Rockwell (**18**) describes the behavior of a ground squirrel which tried to go through the motions of climbing up the support that had led to her nest, after the support and the nest had been removed.

Warren (25) tells of a cat which after several years of failure to imitate another cat's trick suddenly did so.

Washburn and Abbott (26) attempted to find by the use of colored and gray papers whether any brightness could be found that would be indistinguishable from gray to the light-adapted eye of the rabbit. The apparatus was a box with two compartments, each opening by a swing door on the front of the box. The papers were pinned rather than pasted on the doors, to avoid identification by wrinkles, and were changed from experiment to experiment. In the red and gray experiments the door carrying the red paper could be pushed open; the gray door was closed by a button on the inside. Food was in both compartments. To avoid identification of the papers by their intrinsic odor a narrow slit was cut in each at the level where the rabbit's nose touched it in pushing, and a piece of the other paper was placed under the slit. The red or open door was in alternate sides in succeeding experiments, but the rabbits showed no trace of acquiring a kinæsthetic habit of alternating from side to side in their choices. The rabbits learned to discriminate Bradley red paper from Hering gray, numbers 7, 15, and 24, but failed to discriminate it from a paper of the brightness of Hering gray number 46, which is almost black. The results thus agree with those of Yerkes on the dancing mouse and Watson on the monkey, in showing a low stimulating power of red on the retina of the rabbit; and give no proof that red is seen as a color. Some experiments were also made on the brightness value of Bradley saturated blue paper. The results were less conclusive, but gave indications that its value is decidedly lighter than for the human eye, a result which may be compared with the similar observation made on Breed's chicks. "To a certain degree, the rabbit is able to form a habit of choosing the darker of two impressions, irrespective of their absolute brightness." In one series the same gray was presented sometimes with red, in which case it was on the closed door, and sometimes with white, in which case it was on the open door. The rabbit tested chose the gray only 27 per cent. of the time in tests of the first type, and 72.8 per cent. of the time in tests of the second type. Some identification of the absolute brightness of a gray seems to occur, however. The rabbit uses monocular more than binocular vision.

Swift (24) has obtained associations with tone sensations in a dog whose temporal lobes had been destroyed. These reactions, he thinks, in opposition to Kalischer, are not reflexes, since they were learned; and their location must therefore have been in the cortex, though not in the temporal lobe.

Discussion of von Máday's (**14**, **15**) articles on the horse is deferred until a recently published book by this writer, summing them up, can be obtained for review.

Shepherd (**20**) found that three raccoons, which were repeatedly made to watch another raccoon go up an inclined plane and get food, failed to show any signs of inferential imitation when tested alone.

References

1. Breed, F. S. The Development of Certain Instincts and Habits in Chicks. *Behavior Monographs*, 1911, **1**. Pp. 78.
2. Copeland, M. The Olfactory Reactions of the Puffer or Swellfish, *Spheroides maculatus* (Block and Schneider). *J. of Exper. Zoöl.*, 1912, **12**, 363–369.
3. Craig, W. The Expressions of Emotion in the Pigeons. II. The Mourning Dove (*Zenaidura macroura* Linn.). III. The Passenger Pigeon (*Ectopistes migratorius* Linn.). *The Auk*, 1911, **28**, 398–427.
4. Craig, W. Oviposition Induced by the Male in Pigeons. *J. of Morph.*, 1911, **22**, 299–303.
5. Cummings, B. F. Some Features of Behavior in the Courtship Display of the Palmate Newt (*Molge palmata* Schneid.). *J. of Animal Behav.*, 1911, **1**, 305–307.
6. Frisch, K. von. Ueber den Farbensinn der Fische. *Verhandl. d. deut. zool. Gesellschaft*, 1911.
7. Haggerty, M. E. A Case of Instinct. *J. of Animal Behav.*, 1912, **2**, 79–80.
8. Hargitt, C. W. Behavior and Color Changes of Tree Frogs. *J. of Animal Behav.*, 1912, **2**, 51–79.
9. Herrick, F. H. Nests and Nest-Building in Birds. Part II. *J. of Animal Behav.*, 1911, **1**, 244–278. Part III. *Ibid.*, 336–374.
10. Hoge, M. A., and Stocking, R. J. A Note on the Relative Value of Punishment and Reward as Motives. *J. of Animal Behav.*, 1912, **2**, 43–51.
11. Hunter, W. S. Some Labyrinth Habits of the Domestic Pigeon. *J. of Animal Behav.*, 1911, **1**, 278–305.
12. Hunter, W. S. A Note on the Behavior of the White Rat. *J. of Animal Behav.*, 1912, **2**, 137–142.
13. Loeb, J., and Wasteneys, H. On the Adaptation of Fish (Fundulus) to Higher Temperatures. *J. of Exper. Zoöl.*, 1912, **12**, 543–557.
14. Máday, S. v. Das Orientirungsvermögen des Pferdes. *Zsch. f. angew. Psychol.*, 1911, **5**, 54–87.
15. Máday, S. v. Zur Psychologie des Pferdes und des Reitens. *Ber. IV. Kongress f. exper. Psychol.*, 1911, 274–279.
16. Parker, G. H. Effects of Explosive Sounds, Such as Those Produced by Motor Boats and Guns, upon Fishes. *Bureau of Fisheries*, 1911, *Document no. 752*. Pp. 9.
17. Reese, A. M. Food and Chemical Reactions of the Spotted Newt, *Diemyctylus viridescens*. *J. of Animal Behav.*, 1912, **2**, 190–209.
18. Rockwell, R. B. Peculiar Actions of a Striped Ground Squirrel. *J. of Animal Behav.*, 1912, **2**, 218–222.
19. Schaeffer, A. A. Habit Formation in Frogs. *J. of Animal Behav.*, 1911, **1**, 309–336.

20. Shepherd, W. T. Imitation in Raccoons. *Amer. J. of Psychol.*, 1911, **22**, 583–585.
21. Slonaker, J. R. The Normal Activity of the Albino Rat from Birth to Natural Death, its Rate of Growth and Duration of Life. *J. of Animal Behav.*, 1912, **2**, 20–43.
22. Strong, R. M. On the Olfactory Organs and the Sense of Smell in Birds. *J. of Morph.*, 1911, **22**, 619–658, 2 pls.
23. Sumner, F. B. The Adjustment of Flatfish to Various Backgrounds. A Study of Adaptive Color Change. *J. of Exper. Zoöl.*, 1911, **10**, 409–507.
24. Swift, W. B. Psychological Results in Reactions to Tone Before and After Extirpation of the Temporal Lobes. *J. of Animal Behav.*, 1912, **2**, 225–228.
25. Warren, E. R. Delayed Imitation in a Cat. *J. of Animal Behav.*, 1912, **2**, 222–225.
26. Washburn, M. F., and Abbott, E. Experiments on the Brightness Value of Red for the Light-Adapted Eye of the Rabbit. *J. of Animal Behav.*, 1912, **2**, 145–181.

SPECIAL REVIEWS

ANIMAL INTELLIGENCE

The Evolution of Animal Intelligence. S. J. Holmes. New York: Henry Holt and Company, 1911. Pp. v + 296.

An advance announcement of this book reads: "A general account of the evolution of animal behavior from the mollusc and crustacean up to apes and monkeys. The critical point of the transition from instinct to intelligence receives special treatment. One of America's leading scientific authors who saw the manuscript before publication writes: 'Holmes's is the best of the lot, and on the whole, the most interesting because it gives the most *facts*, that is, examples, illustrations, hence animal behavior, incidents, stories, etc. Holmes is immensely well informed.'" The reviewer admits that he was somewhat prejudiced against Professor Holmes's book by this publisher's announcement. He was also rendered curious, and when the book came into his hands he read it at a sitting with intense interest and keen enjoyment. His immediate reaction was to ask the students of an introductory course in comparative psychology to read the book entire. The result was quite as gratifying to the instructor as important for the class, for without exception the men were delighted with Professor Holmes's description of the development of intelligence.

Some weeks later the book was reread more carefully and critically by the reviewer in preparation for the present writing. Naturally, many defects were discovered and the reviewer's judgment concerning the scientific value of the work was somewhat modified.

Professor Holmes has offered an essay on the evolution of intelligence, not a treatise. His book is rather popular in style, sketchy, and introductory to the subject. In spite of the fact that it is poorly written, it is extremely readable, even fascinating to one who is interested in the problems of mental development. For the author appreciates these problems; he has observed animal behavior intensively; he has read widely and he has pondered well the relations as well as the significance of his facts. Unlike most popular essays on scientific subjects, this one has value for the specialist as well as for the general reader.

The Evolution of Animal Intelligence outlines the course of mental development through the discussion of reflex actions, the tropisms, the behavior of the Protozoa, instinct, non-intelligent modifications of behavior, pleasure-pain and the beginnings of intelligence, and the types of intelligence which appear in the arthropods, the lower vertebrates, the mammals, and the primates.

There is nothing noteworthy from the scientific standpoint in the introductory chapters, which deal with reflexes and tropisms, but in connection with his account of behavior in the Protozoa Professor Holmes makes clear his attitude toward tests of intelligence. He is doubtful whether any investigator has thus far satisfactorily demonstrated associative memory in a unicellular organism. "While granting the possibility that future work may compel us to modify our conclusion," he writes, "it may be said that, thus far, there is no unmistakable evidence that the protozoa are capable of forming true habits or of learning by association" (p. 89). Unfortunately for the reader, this discussion of the educability of the Protozoa is not preceded by such a definition of habit formation and of associative memory as would prepare him to react critically to the author's statements.

The two chapters which are devoted to the description of instinct and of its evolution are decidedly unsatisfactory to the reviewer. They fairly well present many of the essential facts concerning instinct and, in a conventional way, they offer an account of the chief theories of the origin of instinct, but they lack the freshness and originality which are characteristic of most parts of the book.

In his chapter on the evolution of instinct, the author quotes with apparent approval the following words of Professor C. O. Whitman: "Instinct precedes intelligence both in ontogeny and in phylogeny, and it has furnished all the structural foundations employed by intelligence." At the beginning of the next chapter he quotes, with approval one must infer, Father Wasmann's words: "Both elements, automatism and plasticity, are found in different proportions with all animals from the highest to the lowest." To the reviewer it seems that instinct is one form of automatism and that intelligence is an expression of plasticity. Evidently the author would not accept this statement, for he repeatedly asserts that intelligence has developed from instinct. It certainly is fair to object that the view of Professor Whitman which receives Professor Holmes's support and which he at one point says is commonly accepted by psychologists (p. 164) is not the only view which may be defended.

As it happens, the reviewer numbers himself among those who do not conceive of intelligence as having developed from instinct.

In his account of modifications of behavior, the author points out that there are certain modifications which should be considered non-intelligent. Indeed he states that certain forms of modifiability are probably coextensive with animal life and that, if we accept these modifications as intelligent, we must admit that even the cells of the multicellular organism are intelligent. Intelligent behavior, we are told, differs from non-intelligent behavior in that the former involves "associations" (p. 164). These associations, the author states, are in some cases associations of sense experiences with acts which are either pleasurable or painful. In other cases they are associations of ideas. The former of these associations represent a much lower stage in the development of intelligence than do the latter. At some points in Professor Holmes's description, it is not clear whether he accepts the association of sense impressions with affective experiences as a form of intelligence. For example, on page 181 he writes: "In the Cœlenterata behavior, although of the reflex type, is often highly plastic and capable of being modified in many ways as the result of previous experience; but while intelligence has often been claimed for these forms, there is, in the opinion of the writer, no case in which the formation of associations is satisfactorily proven." Either in this statement the author has misused the word "experience," or he has contradicted himself. Similar contradictory statements might be quoted from other portions of the book; and fairly strong support might be adduced for the statement that the author has not with sufficient clearness defined such important terms as habit, association, associative memory, and intelligence.

In the chapter on primitive types of intelligence in crustaceans and molluscs, Professor Holmes thus briefly sums up the results of studies which have been made concerning the educability and intelligence of the invertebrates. The Protozoa furnish no evidence of ability to acquire associations. The Cœlenterata present no convincing evidence of the formation of associations. "The same statement may also be risked for . . . the Vermes. The behavior of Echinoderms is certainly complex and plastic to a remarkable degree, but even in this group the power of forming associations is very doubtful." In the Crustacea and the Insecta the existence of intelligence is admitted and numerous examples are offered of intelligent modes of behavior. Indeed the activities of certain crustaceans and insects are most effectively described in chapters 9 and 10. In

the latter chapter, Professor Holmes has written (p. 201): "We are certainly justified in concluding that insects are not mere reflex machines incapable of learning by experience. They can form associations very quickly in many cases. They give evidence of memory. They have a remarkable ability for retaining impressions of topographical relations. We may not be compelled to admit that they have ideas, but it must be granted, I think, that a wasp which after cutting a caterpillar in two and carrying away one part, came back and searched diligently for the remainder, retained somehow an impression of the missing part and its location. If out of sight it was not out of mind."

The intelligence of the lower vertebrates is interestingly characterized by the presentation of the results of a number of studies of fishes, amphibians and reptiles. It is pointed out that associations (intelligence) do not necessarily depend upon the cerebral cortex. A careful comparison of many of the statements which appear in the author's chapter on intelligence in the lower vertebrates with statements in his chapters 7, 8, and 9 is likely to leave the reader in doubt concerning the physiological and psychological characteristics of intelligent acts and even more so concerning their structural relations.

The examples of different modes of behavior, non-intelligent and intelligent, which make up the greater part of this book are admirably chosen and, in addition to giving the reader the impression of extensive knowledge on the part of the author, they serve to acquaint him with many of the most important facts which the study of behavior has revealed. It is perhaps unfortunate that Professor Holmes in his account of the intelligence of the apes should have chosen Professor Witmer's description of "Peter" to represent the intelligence of the chimpanzee. For Peter, it should be remarked, was a trick animal whose behavior was observed only after many months of training, and even then for only brief periods. Had the author given the matter further consideration, he would doubless have concluded that concerning behavior of whose history in the individual we know nothing we can say little with safety. Whether it is intelligent or non-intelligent, whether it is indicative of the presence of ideas or of images cannot be decided. One might compare the behavior of Peter, as it is described by Professor Witmer, with the behavior of such a trained horse as Clever Hans, the observer of whose performances would be likely to make inferences regarding the degrees and types of intelligence of the horse which in the light of a careful study of the development of the animal's behavior are amusing.

The Evolution of Animal Intelligence presents particular facts in abundance and generalizations and theories in such fashion as to inform the reader and, at the same time, suggest interesting problems. The book contains little concerning the methods of studying animal behavior and it will prove more useful to those who desire a sketch of behavior than to those who desire to learn how to observe it or how to solve specific problems concerning intelligence.

Robert M. Yerkes
Harvard University

Animal Intelligence: Experimental Studies. E. L. Thorndike. New York: The Macmillan Co., 1911.

The present volume consists mainly of various previously published papers, a few of which have been for some time out of print. In thus bringing together his contributions in the field of animal psychology, Dr. Thorndike has rendered a service for which students of this subject have reason to feel grateful. However they may be inclined to differ from the conclusions of the author as to the nature and limitations of the animal mind, they must needs recognize the important part that his investigations have played in the development of our knowledge of animal psychology.

While Dr. Thorndike has added many interesting facts concerning the behavior of animals, the value of his work lies not so much in his contributions to knowledge as in the example of his method. Since the appearance of the monograph on *Animal Intelligence* in 1898 the labyrinth and the puzzle-box have been the favorite apparatus for testing the mental capacity of the animals studied. The numerous experimental studies which followed close upon the investigations of Dr. Thorndike have been carried out, for the most part, in a more careful and critical manner than that which formerly prevailed in the study of the mental life of the higher animals. The crusade against anecdotal psychology and the undue exaltation of the intelligence of animals was a wholesome influence which was perhaps all the more potent on account of the somewhat extreme position of the author. And if several of the negative conclusions to which Thorndike was led have not been upheld by later investigators, the positive conclusions which the latter have drawn are based on a more adequate foundation as a result of applying the methods of study that Thorndike employed. William of Occam's razor is an unsafe instrument in the investigation of the mental life of animals, but it is one whose constant employment is nevertheless unavoidable.

Besides the monograph on Animal Intelligence, the volume contains an introductory chapter on The Study of Consciousness and the Study of Behavior, and chapters entitled The Instinctive Reactions of Young Chicks, A Note on the Psychology of Fishes, The Mental Life of the Monkeys, Laws and Hypotheses of Behavior, and The Evolution of the Human Intellect. The introductory chapter and the chapter on Laws and Hypotheses of Behavior are new. The first consists essentially of a discussion of the proper subject matter of psychology. Thorndike joins issue with those who would limit psychology to the consideration of consciousness. As a matter of fact such a limitation is never made in practice, however desirable it may be deemed in theory; the phenomena of behavior and those of conscious life are so closely interwoven that it is impracticable to deal with them separately, and psychology must perforce continue to occupy itself with both sides of the impassable cleft that separates states of consciousness from their physiological concomitants.

In the chapter on Laws and Hypotheses of Behavior there is considerable matter for reflection. There are two laws of the modification of behavior which, according to Thorndike, are of especial value in explaining higher manifestations of mental activity. The first, or the law of effect, is that acts which bring satisfaction tend to be repeated, while those which produce pain tend to become discontinued, the strength of the connections formed being proportional to the intensity of the resulting feelings and the smallness of the interval of time by which they are separated from the act that produced them. The second principle, the law of exercise, is that "any response to a situation will, other things equal, be more strongly connected with the situation in proportion to the number of times it has been connected with that situation and to the average vigor and duration of the connections."

Satisfaction and discomfort are admitted to be but very roughly correlated with what is favorable and unfavorable respectively to the animal. What is sought after and produces satisfaction may at times be deleterious, but Thorndike states that "upon examination it appears that the pernicious states of affairs an animal welcomes are not pernicious *at the time, to the neurones*. We may learn bad habits, such as morphinism, because there is incomplete adaptation of the body state to the temporary interest of its ruling class, the neurones."

Direct evidence that pleasure-giving and pain-giving experiences are related in these ways to the welfare of the neurones is not adduced,

but the conclusion is incorporated as an element of a further hypothesis to explain the law of effect. The modifications of behavior which this law formulates involve changes in the connections between neurones, probably at the synapses, so that certain lines of communication are rendered more permeable than others. Those connections are made more permeable which result in favoring the life processes of the neurone, and those are weakened which result in impeding these processes. It naturally follows that "learning by the law of effect is thus more fully adaptive for the neurones in the changing intimacy of whose synapses learning consists, than for the animal as a whole." Profiting by experience through forming associations rests upon the adaptive behavior of the neurones.

This interesting hypothesis of Thorndike involves, as do most hypotheses concerning the problem of learning, a number of unproven assumptions. It may be questioned if the law of exercise may not be capable of a simpler explanation without appealing to a selective activity on the part of the neurones, or any primary tendency to seek the welfare of these elements.

The discussion of the preceding laws paves the way for the consideration of imitation which may be explained, according to Thorndike, "by the laws of instinct, exercise and effect." The important conclusion is drawn that "the idea of a response is in and of itself unable to produce that response," imitation in all cases, except those of the purely instinctive type, being the indirect outcome of the pleasure-pain type of behavior. The connections established by reasoning fall under the same far-reaching principles of explanation.

Adequate discussion of the fundamental questions raised in this chapter would require more space than can be devoted to them here. The treatment of these questions which Dr. Thorndike has given cannot fail to be suggestive and stimulating both to the general psychologist and the special student of animal behavior.

S. J. Holmes

University of Wisconsin